Operation And Maintenance Of Slow Speed Pumping Engines

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Slow speed pumping engines may be defined as engines of speeds up to 500 or 600 rpm. These engines are generally single or twin cylinder design and may be either two or four cycle.

As a basis for this discussion on operation and maintenance of slow speed pumping engines, it would be well to review the basic principal of operation of both two and four cycle engines. This may seem unnecessarily elementary, but it has been our experience that even among those who work with engines many do not have a clear picture of the manner in which an engine operates—this appears to be particularly true of the two stroke cycle engine. Certainly, the fundamentals need to be clearly understood if good operation and maintenance are to be obtained.

First, let us consider the four stroke cycle engine which is so named because four strokes (two revolutions of the crankshaft) are required to complete the cycle. The four strokes may be listed as follows:

1. Compression Stroke — during which time the piston is moving forward and compressing the air-fuel mixture — both intake and exhaust valves, of course, are closed.
2. Power Stroke which follows compression and ignition of the charge—both intake and exhaust valves closed. Piston is forced back delivering useful work into crankshaft.
3. Exhaust Stroke—exhaust valve open — intake valve closed — piston moves forward forcing exhaust gases from cylinder.
4. Intake Stroke—intake valve open — exhaust valve closed — piston moves back drawing in a new air-fuel mixture for the next cycle.

By comparison, the two stroke cycle engine requires only two strokes (or one revolution of the crankshaft) to complete the cycle. They are the compression stroke and the power stroke. In other words, the exhaust and intake are eliminated as individual strokes. Of course, these functions must be accomplished in a two cycle engine as well as in a four cycle engine, but it is the manner in which this is done which is not always clearly understood.

Let us consider the port scavenging two cycle principal which is the design used by all two cycle, slow speed pumping engines. Now a port scavenging engine is one in which the inlet and exhaust valves are simply ports in the cylinder well which are opened and closed by the body of the piston as it travels past them.

We see then that a two cycle port scavenging engine functions in this manner: as the piston moves forward on the compression stroke, the back side of the piston, being utilized as a scavenging pump, is drawing in another charge of air and fuel into the scavenging chamber. This process continues as long as the piston is moving forward on the compression stroke. As the piston approaches dead center the spark occurs, igniting the charge, and as combustion takes place the piston is forced back on the power stroke. As soon as the power stroke starts, the check valve in the intake manifold closes so that the new charge is then trapped in the scavenging chamber. As the piston continues back on the power stroke, the back side of the piston then compresses the scavenging charge to a few pounds pressure. As soon as the piston uncovers the exhaust ports, the burnt gases blow into the exhaust system so that by the time the piston opens up the intake ports the main charge of the exhaust has already been dissipated and the scavenging charge sweeps into the cylinder scavenging the remaining exhaust gases and filling the cylinder with another mixture of air and fuel. So you see that the exhaust and the intake on a two cycle engine, instead of requiring two complete strokes, are accomplished while the piston is approaching and leaving back dead center.

This brief review of the basic principals of engine operation serve to bring out some points that need to be considered in the operation and maintenance of pumping engines.

First, the ability of any engine to successfully carry its load over a period of time is influenced by the ability of the engine to rid itself of exhaust gases. Always follow the manufacturer's recommendation as to size and length of exhaust pipe. If a muffler is to be used, be sure that it has adequate capacity. Restriction in the exhaust increases engine operating temperature, adds to lubrication problems, shortens ring life and valve life. On a two cycle engine, the exhaust system needs special consideration because good scavenging of the engine is dependent upon a tuned exhaust system. Tuning the exhaust system simply means selecting the proper length of pipe for the speed at which the engine is to run so that the pressure waves which are set up within the pipe by the engine exhaust will aid the scavenging process. This means that for any given speed there is only one length of pipe that will give optimum performance. Complete scavenging, you see, is the secret of good performance and anything that hinders the process is harmful—either a poor exhaust system or a restriction in the air intake system.

This leads us to the second point which should be considered and that is the air intake system. Any restriction here reduces the ability of the engine to breathe, causes loss of power, and on a two cycle engine may seriously affect scavenging. The most common cause of air restriction is poor air cleaner maintenance.. Never use heavy oil in an oil bath air cleaner. This is particularly dangerous in cold weather. Also be sure to inspect at regular intervals and change oil if necessary.

A third point which needs to be considered is the fuel gas system. This must be arranged so as to assure the engine of an adequate supply of gas at the proper pressure. To accomplish this, a volume tank and a regulator should be installed. The volume tank should be as close to the engine as possible—preferably not more than six or eight feet—and the regulator should be just ahead of the tank. If the regulator is a great distance from the engine as we sometimes find, the time lag makes it difficult for the regulator to supply the gas when required. Still another consideration is the size of the orifice in the regulator. It is possible to have a regulator of ample size but to have it equipped with an orifice which is too small to handle the necessary volume of gas at the existing pressure differential. Always check for orifice size when installing a regulator.

Also be sure that the gas pressure is not too high. Most engines require only four to six ounces of pressure. An engine can be forced to take more gas than it needs; however, when this happens, its ability to carry the load is reduced due to improper mixture of gas and air. For engines equipped with carburetors, the air-fuel mixture is controlled by the setting of the load screw on the carburetor. A good rule of the thumb to follow for adjusting the mixture is as follows: with engine under load and running at desired speed, turn load screw in leaning the mixture until the engine begins to lose speed — then back the screw out 1/4 to 1/2 turn from this point. This will be the most efficient carburetor setting.

The fuel gas should be clean and free from entrained liquids. If liquid hydrocarbons are allowed to carry over into the engine, serious damage will be caused to the cylinder, piston and rings. Adequate scrubbers should be installed if such conditions are present.

Let us turn now to the mechanics of engine maintenance. Most single and twin cylinder pumping engines use tapered roller bearings for main crankshaft bearings. The advantages are low friction loss and long life. Bearing adjustment is rarely required; in fact, many non-adjustable bearings are used, thus making it impossible for them to be misadjusted. When working with adjustable bearings, great care must be taken to follow the manufacturer's recommendation since misadjustment may cause serious damage.

Crank pin bearings are usually bronze backed, babbitt lined, precision bearings which require no hand scraping. They may or may not be shim adjusted. If shims are used, they may be adjusted to compensate for wear. However, here again great care must be taken. Frequently bearing failures are caused by removing shims in a mis-guided attempt to eliminate a so-called "crank pin knock" which actually is a combustion knock caused by improper spark timing, too rich an air-fuel mixture, or improper scavenging. A strictly mechanical knock is very difficult to distinguish from a combustion knock and any knock should be carefully investigated before any corrective measures are undertaken. Certainly, the crank pin bearing clearance should never be reduced without first checking to see what the clearance is. One way in which this may be done is by plastic gauge indicator which when installed between the bearing and the crank pin crushes to show the actual clearance.

Bearings in power take off clutches are normally grease lubricated and need attention approximately once a week except when clutches are equipped for extended periods of service which we will discuss later. In this case, the main clutch bearings are oil lubricated with a constant oil level feed cup and the pilot bearing is a packed for life bearing.

One of the most important considerations in clutch maintenance is the side pull loading due to belt tension and sheave location. Always locate the sheave as far in on the clutch shaft as possible and use as short sheave center distances as practical since this greatly reduces bearing loadings. Be sure never to use more tension on the "V" belts than necessary. It is very easy to put a destructive loading on the clutch if judgment is not used in the tensioning of the belts. The danger, of course, is proportionately greater on drives using long center distances and a large number of belts because it becomes more difficult to judge tension and there is the possibility of the load not being evenly distributed across the width of the sheave. There is a real need for a simple foolproof method of establishing and checking belt tensions.

Crosshead type engines generally employ splash lubrication for the crankcase and mechanical force feed lubricators for the cylinder and piston rings. Since the crankcase in this type of an engine is completely separated from the combustion end of the engine, the crankcase oil suffers no contamination from the products of combustion; therefore, no filtering equipment is needed and the oil stays clean and useable for long periods. Oil need not be changed oftener than 8,000 to 10,000 hours of operation. An important feature of the splash lubricated design is the settling chamber which is located at the crosshead end of the crankcase. It is nothing more than a quiescent chamber which catches and holds any dirt or foreign matter which the oil splash carries into it. Thus, any foreign matter in the oil will tend to collect in the settling chamber instead of being free to recirculate. It should be remembered, when changing crankcase oil, to drain and clean the settling chamber for it plays an important role in the crankcase lubrication system. Since the crank case is separated from the combustion end of the engine by a stuffing box on the piston rod, not only does the oil remain free from contamination but also wear of the piston rings does not cause crankcase oil consumption. As long as the stuffing box is in good condition, it should not be necessary to add more than one quart of oil to the crankcase every two to three weeks. Excessive leakage past the stuffing box should be corrected immediately since oil that leaks thru the stuffing box is carried over to the combustion chamber and causes stuck rings, and pluggged ports.

Trunk type piston engines usually employ pressure lubrication to principal parts with splash or spray to other parts. In these engines the oil is subject to contamination from oxidation and combustion blow by, and also condensation, if low operating temperatures are permitted. Therefore, filters are used to keep the oil in good condition. Always be sure to change filters as recommended. However, since oil increases in acidity from use, the use of filters does not mean that oil changes are no longer important. Be sure to follow instructions.

The majority of slow speed pumping engines employ either condenser or thermosyphon cooling systems. Because of their simplicity and low maintenance requirements, they are very well suited to this type of engine. For cold weather protection, permanent base anti-freeze is recommended. When using anti-freeze it is wise to thoroughly mix the correct proportion of water and anti-freeze before pouring into the radiator. The most important maintenance consideration on the cooling system is to see the radiator core is kept clean both inside as well as out and that the pressure cap is in good condition and screwed tightly in place so as to prevent loss of water.

When considering the ignition system, one of the important points to remember is keeping the spark plug properly gapped. In operation, the spark discharge causes erosion of the electrodes which increases the spark gap. As the gap increases, a greater and greater electrical load is imposed upon the magneto. Regular gapping of the spark plug will probably do more to prolong magneto life than any other single thing. Also when replacing a spark plug, be sure that the gasket is in good condition and that the gasket seat in the cylinder head is clean and that the plug is screwed in tightly against the gasket. The spark plug depends upon good contact at this point for proper cooling.

The magneto is equipped with an impulse coupling which automatically retards as it produces a strong starting spark. As the engine speed increases, centrifugal force throws the impulse. coupling out of operation and the spark then is advanced to the proper running position. Not all engines require the same impulse coupling lag so always be sure when installing a new magneto that it has the proper lag for the engine on which it is being installed. If the wrong impulse coupling lag is used, the running spark may be seriously out of time.

Preventive Maintenance

In recent years there has been a great deal of emphasis on a positive program of preventive maintenance and the equipping of engines with accessories which will allow extended periods of operation without the necessity of an operator in attendance. An auxiliary lubricating oil reservoir with liquid level controllers to automatically maintain the proper oil level in the crankcase and cylinder lubricator may be used. Such a reservoir will be adequate to carry at least a month's supply of oil. The engines may also be equipped with safety devices to guard against overheating, overspeeding, low oil level, or low oil presssure. All accessories are constructed for extended life. Spark plugs for instance of heavy duty construction are available with electrodes made of materials which resist the eroding affects of the spark discharge. These plugs will hold the correct gap setting for many months of continuous operation which not only gives long spark plug life but also contributes considerably to long magneto life since it eliminates the electrical overload from the magneto which as we have mentioned is caused by electrode erosion and the resultant large spark gap. The high tension spark plug wire is also available with plastic covering which is resistant to atmospheric conditions and corona affect given long dependable service.

Power take off clutches can be equipped with a constant level oil cup feed on the main bearings and a sealed "packed for life" pilot bearing so that no attention is required for periods up to one year.

Engines equipped with such extended life accessories may have a maintenance schedule such as follows:

Monthly

Fill crankcase and lubricator oil reservoir.

Brush bugs from radiator core.

Drain scavenging chamber.

Inspect and replace oil in air filter if necessary.

Semi - Annual

Inspect and, if necessary, replace spark plug.

Inspect and tighten all exposed nuts and bolts and other fasteners.

Annual

Replace spark plug and cable.

Shop magneto.

Inspect governor, and replace worn parts.

Clean and check lubricator, and replace any worn parts.

Clean crankcase breather cap.

Thoroughly clean dirt accumulation from radiator core. Inspect for leaks and other defects.

Replace radiator hose connections.

Grease fan bearings.

Inspect fan belt, and replace, if necessary.

Drain and flush crankcase and settling sump.

Inspect and clean carburetor and regulator.

Inspect and adjust clutch. Inspect, grease and/or replace clutch pilot bearing.

Flush and refill clutch oil sump and cup.

Inspect and clean intake and exhaust ports.

Bi - Annual

Inspect and, if necessary, replace piston rings.

Inspect and clean stuffing box packing rings.

Inspect and, if necessary, adjust crank pin bearing.

Inspect and, if necessary, replace crosshead pin bearing.

If such a schedule is followed, it will not only reduce costly unexpected down time but will promote longer engine life because difficulties will be found and corrected before they cause serious damage. However, it should be remembered that the above is intended only as a guide to cover the principal points in a maintenance program. It is of course impossible to anticipate all the possible points of trouble in any mechanical equipment and the success of any such program will depend upon the interest and good judgment of the operating personnel.